FOOD OF SALMONID FISHES OF THE WESTERN NORTH PACIFIC OCEAN

SPECIAL SCIENTIFIC REPORT—FISHERIES No. 237

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

EXPLANATORY NOTE

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for official use of Federal, State or cooperating agencies and in processed form for economy and to avoid delay in publication.

United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service, Arnie J. Suomela, Commissioner

FOOD OF SALMONID FISHES OF THE WESTERN NORTH PACIFIC OCEAN

by

George H. Allen and William Aron
Department of Oceanography
University of Washington

Special Scientific Report--Fisheries No. 237

University of Washington, Contribution No. 216

Washington, D. C.
January 1958

TABLE OF CONTENTS

FIGURES

TABLES

Nos. Page

The research reported herein was carried out as part of the participation of the United States in the investigational program of the International North Pacific Fisheries Commission. The University of Washington carried out the work under U. S. Fish and Wildlife Service Contract No. 14-19-008-9303 and Office of Naval Research Contract Nos. Nonr-477(10), Project 083-012 and Nonr-477(01), Project 083-072.

Abstract

The stomach contents of salmon caught in the Japanese oceanic gill-net fishery were studied. Data are presented on the diets of three species of salmon: *Oncorhynchus nerka* (sockeye), *O. keta* (chum), and *O. gorbuscha* (pink). The 20 fishing areas were grouped into three major regions, and data for each species of salmon were treated separately according to region of capture. The contents of individual stomachs were examined and classified. There was little variation between the stomach contents of the same species caught in the same area, but there were marked differences between species. No relationship has been established between plankton samples and the animal forms found in the stomach contents. Use of the Isaacs-Kidd midwater trawl may prove satisfactory for sampling the food of salmon in future investigations.

Food of Salmonid Fishes of the
Western North Pacific Ocean

Japan, Canada, and the United States formed the International North Pacific Fisheries Commission in 1953. The Commission's primary concern is to study the conservation and utilization of the fisheries resources of the northern Pacific. As part of the researches instituted by the Commission, the University of Washington Department of Oceanography undertook to study the food of salmonid fishes in the oceanic stage of their life cycle.

The purpose of the food-study program was to determine which animals were important to the diet of the salmon. This knowledge would permit extensive research into the distribution of such food organisms in the open ocean and, in turn, into the distribution of salmon. The diets of three species of *Oncorhynchus* are reported in this paper: *O. nerka*, the sockeye salmon; *O. keta*, the chum salmon; and *O. gorbuscha*, the pink salmon. The diet of the king salmon, *O. tshawytscha*; the silver salmon, *O. kisutch*; and the steelhead, *Salmo gairdnerii*, also were investigated, but the data are insufficient to justify inclusion in this report.

Material and Methods

The fish used in this study were purchased by the United States Fish and Wildlife Service from the Japanese oceanic gill-net fishery. Table 1 gives the location and date of catch, number of fish in the catch, and the sex and fork length of the fish.

For purpose of comparison, the fishing areas are grouped into three major regions (Fig. 1):

Figure 1.--Regions of capture for fish used in this study.

Table 1.--Location, date of catch, number, sex, and lengths of salmon from the Japanese high seas fishery in 1955

Area	N. Lat.,	W. Long.	Date of Catch	Species	Number of Fish M	F	T	Fork Length Range cm.	Mean cm.
1	57° 22'	154° 00'	June 30	Sockeye	2	3	6*	51-61	57
				Chum	0	2	2	61	61
				Pink	0	0	0	0	0
2	53 25	153 50	July 10	Sockeye**	5	15	20	50-62	55
				Chum	3	4	8*	54-59	56
				Pink	0	0	0	0	0
3	52 42	154 12	July 20	Sockeye	0	5	5	54-56	55
				Chum	0	3	3	48-58	55
				Pink	9	12	21	44-58	52
4	52 03	154 12	July 20	Sockeye	5	4	9	46-61	56
				Chum	0	1	1		56
				Pink	0	0	0	0	0
5	52 03	154 20	Aug. 10	Sockeye**	6	14	20	50-64	57
				Chum	0	0	0	0	0
			July 30	Pink*	2	6	8	45-53	48
			Aug. 10		5	20	25		
6	52 02	154 30	July 30	Sockeye**	8	12	20	50-63	56
				Chum	1	0	1		54
				Pink	0	0	0	0	0
7	51 22	154 00	June 30	Sockeye*	4	7	11	52-60	57
				Chum	2	2	4	52-59	56
				Pink	0	0	0	0	0
8	49 48	156 60	July 27	Sockeye	11	14	25	53-63	57
				Chum	4	5	9	51-65	59
8a	49 48	156 50	Aug. 10	Pink	7	8	15	45-53	48
8b	48 36	157 27	Aug. 10	Pink	5	8	13	48-57	52
9	50 18	158 52	July 30	Sockeye	3	10	13	49-61	53
				Chum	0	3	5*	55-56	56
				Pink	6	11	17	44-50	47
10	51 33	159 04	July 14	Sockeye	6	4	10	50-62	57
				Chum	5	14	21*	51-60	56
				Pink	19	4	23	43-54	47
11	53 15	161 10	July 27	Sockeye	10	12	22	51-65	58
				Chum	1	3	4	55-60	57
				Pink	15	8	23	43-56	48
11a	52 48	161 02	July 13	Chum	1	0	1		60
				Pink	1	1	2	44-47	45

Area	N. Lat.,	E. Long.	Date of Catch	Species	Number of Fish M	F	T	Fork Length Range cm.	Mean cm.
12	50° 13'	161° 57'	Aug. 10	Sockeye	16	6	22	48-60	53
				Chum	4	2	7*	55-59	56
				Pink	17	7	24	50-59	53
13	53 29	164 21	July 13	Sockeye	11	14	25	44-55	50
				Chum	0	2	2	53-57	55
				Pink	11	4	15	44-53	49
14	48 33	165 30	June 1	Sockeye	4	6	10	51-58	54
				Chum	3	7	10	49-56	53
				Pink	13	1	14	44-49	47
15	49 18	167 49	June 22	Sockeye	7	8	15	48-61	54
				Chum	10	12	22	47-68	56
				Pink	19	1	20	44-53	47
16	48 32	167 50	June 1	Sockeye	4	6	10	51-62	55
				Chum	9	7	17*	49-58	52
				Pink	20	0	24*	44-50	47
17	48 45	168 00	June 1	Sockeye**	3	8	11	45-57	51
				Chum	2	3	5	51-54	53
				Pink	1	1	2	45-50	47
17a	48 45	168 00	June 23	Chum*	0	0	1*		55
				Pink	9	4	13	49-58	55
18	49 40	169 11	June 22	Sockeye	10	14	24	51-58	55
				Chum	6	3	9	55-62	59
				Pink	22	2	24	46-53	48
19	48 43	170 23	May 18	Sockeye	3	14	17	49-57	52
				Chum	2	1	4*	53-54	53
				Pink	14	0	14	45-48	46
19a	48 38	170 23	May 19	Chum	2	1	6*	59-60	59
20	48 50	173 00	May 18	Sockeye	9	8	17	47-58	54
				Chum	8	6	14	49-59	53
				Pink	0	0	0	0	0

* Total includes fish of unknown sex.

** The salmon from these areas (2, 5, 6, 7, 17, and 17a) are represented by multiple samples, but the samples were taken on the same day, except for Area 5 where samples were taken on different days.

Region A (Areas 1-7) - Okhotsk Sea off the west coast of Kamchatka

Region B (Areas 8-13) - North Pacific Ocean off the east coast of Kamchatka between 49° 30' N and 53° 30' N.

Region C (Areas 14-20) - North Pacific Ocean from 165° 00' E. to 175° 00' E., and 48° 00' N. to 50° 00' N.

Fish were frozen after capture, and stored for periods varying from one month to a year. They were then thawed, and morphometric measurements were made, sex and degree of maturity were determined, and the digestive tracts anterior to the initial insertion of the pyloric caecae were removed. The digestive tracts were preserved in 95 percent ethyl alcohol and stored in 8-ounce screw cap jars. For chum salmon only those stomachs which were considered to contain food items were made available for study. For pink and sockeye salmon, all stomachs regardless of content were made available. These data are summarized in table 2.

Table 2.--Number of salmon stomachs studied

Region	Sockeye		Pink		Chum	
	Total number avail.	No. with identifiable remains	Total number avail.	No. with identifiable remains	Total number avail.	No. with identifiable remains
A	91	51	46	31	19	16
B	117	85	132	118	49	45
C	104	91	111	107	88	83
	312	227	289	256	156	144

Stomach contents were removed in most cases on the same day that the stomach was obtained from the fish. However, some stomachs were not processed for periods up to two weeks. No difference in the state of preservation of the contents of these stomachs could be discerned.

The contents of most of the stomachs were preserved in screw cap vials varying in capacity from 28 to 42 milliliters. The contents of stomachs which contained large items, such as fish and squids, were preserved in 8-ounce screw cap jars. The preservative used was 95 percent ethyl alcohol.

The volume of the stomach content was determined by visual comparison with a vial which had been graduated in milliliters. For some larger items volume was determined by displacement in water. The displacement volumes were multiplied by a factor of 5 (Redfield, 1941) and added to the settled volume. All results are reported as settled volume in milliliters.

Because a detailed analysis of the food items in each stomach could not be undertaken, items were listed as follows: copepods, euphausiids, amphipods, pteropods, fish, squid, and crustacean larvae. An estimate of the percentage composition of these forms in each stomach was made by examining the total contents, or an aliquot sample was taken and compared visually with the remainder of the stomach contents to detect any obvious sampling error. The estimated percentage composition was an approximation; however, the distinct differences of feeding behavior between species minimized errors from the rapid method of study employed.

Results

Each species is treated separately according to region of capture. The three species are then compared to evaluate the differences in feeding behavior. Table 3 gives for the stomachs having identifiable remains the average volume, and the maximum volume for a single stomach for the three species by regions. Tables 4, 5, and 6 give in percent the frequency of occurrence and the volume of the different food items in the stomach contents of the three species.

Table 3.--Volumes of stomaches having identifiable remains

Region	Average volume, ml.			Maximum volume for a single stomach, ml.		
	Sockeye	Chum	Pink	Sockeye	Chum	Pink
A	13	15	22	25	40	78
B	20	20	19	54	30	69
C	22	25	24	100	75	84

Table 4.--Food items in the stomach contents of sockeye salmon

Food item	Region A V 1/	Region A F 2/	Region B V 1/	Region B F 2/	Region C V 1/	Region C F 2/
Copepods	0.0	0.0	1.0	8.2	49.5	74.7
Euphausiids	1.3	9.8	4.0	16.4	31.0	70.3
Amphipods	64.6	88.2	85.0	100.0	4.0	29.6
Pteropods	2.9	5.9	3.0	10.6	5.0	23.0
Fish	0.3	2.0	4.0	5.9	11.0	16.4
Squid	4.9	9.8	2.0	7.1	1.0	3.3
Crustacean larvae	26.0	37.2	1.0	3.5	0.0	0.0

Table 5.--Food items in the stomach contents of chum salmon

Food item	Region A V 1/	Region A F 2/	Region B V 1/	Region B F 2/	Region C V 1/	Region C F 2/
Copepods	2.0	12.5	5.9	44.4	10.1	37.3
Euphausiids	3.0	25.0	15.7	55.1	50.1	84.3
Amphipods	12.1	87.5	30.1	95.6	7.8	69.9
Pteropods	19.1	37.5	9.4	15.6	11.1	33.7
Fish	10.6	18.8	11.7	26.7	19.0	38.6
Squid	17.1	31.3	23.3	55.6	1.1	15.7
Crustacean larvae	35.8	56.3	3.8	29.9	0.8	10.8

Table 6.--Food items in the stomach contents of pink salmon

Food item	Region A V 1/	Region A F 2/	Region B V 1/	Region B F 2/	Region C V 1/	Region C F 2/
Copepods	0.0	0.0	1.0	5.1	41.7	85.0
Euphausiids	0.3	3.3	7.6	28.8	20.2	56.1
Amphipods	56.9	90.0	49.0	93.2	12.5	66.3
Pteropods	10.1	13.3	3.5	35.6	5.5	41.1
Fish	13.7	53.3	20.5	60.2	17.0	48.6
Squid	6.7	36.7	1.7	16.1	3.1	19.6
Crustacean larvae	12.2	70.0	16.7	77.1	0.0	0.0

1/ Volume contribution in percentage

2/ Frequency of occurrence in percentage

Food of the sockeye salmon

A marked difference was found in the amount of material in stomachs of fish captured in Region A from those captured in Regions B and C. These differences were also reflected in the quantitative differences of individual food organisms found in the three regions. In Regions A and B amphipods formed the major food of the sockeye, and in Region C copepods and euphausiids were of primary importance. In Region A only two items, amphipods and crustacean larvae, contributed more than 10 percent to the volume of the diet. In Region B only amphipods contributed more than 10 percent to the volume of the diet, and in Region C euphausiids, copepods, and fish were found in volumes exceeding 10 percent. All other items were of secondary importance in terms of volume, although the frequency of their occurrence may be high. Pteropods and fish, for example, were found in 23 and 16 percent of the stomachs from Region C; however, they contributed only 5.0 and 11.0 percent to the total volume of the diet. Amphipods seemed to have a wide geographic distribution. In Region C, where they contribute only 4.0 percent of the volume to the diet, they are found in 29.6 percent of the stomachs examined.

Food of the chum salmon

The amount of material found in the chum salmon stomachs increased as the area of capture became more oceanic. In Region A all items other than copepods and euphausiids contributed volumes in excess of 10 percent to the diet of the chum. The copepods and euphausiids, which contributed only 2 and 3 percent to the volume of the diet, were found in 12.5 and 25.0 percent of the stomachs. In Region B each of four items, euphausiids, amphipods, fish, and squid, contributed quantities in excess of 10 percent to the volume. The remaining items, copepods, pteropods, and crustacean larvae, although of secondary importance volumetrically, were found frequently in the stomachs. Copepods, for example, although only contributing 5.9 percent of the volume, were found in 44.4 percent of the stomachs. In Region C four items, euphausiids, copepods, pteropods, and fish, each contributed quantities in excess of 10 percent to the volume. The remaining items, although appearing frequently in the stomachs, seemed to be of lesser importance to the diets of fish from this region. Amphipods were found in 69.9 percent of the fish, although they contributed only 7.8 percent of the total volume.

Food of the pink salmon

No major differences appeared in volume of stomach contents of pink salmon from the different areas. In Region A each of four items, amphipods, pteropods, fish, and crustacean larvae, contributed more than 10 percent to the volume of the diet of the pink salmon. Of the four, amphipods accounted for 56.9 percent of

the total volume. Squid were found in 36.7 percent of the stomachs but represented only 6.7 percent of the food volume. In Region B only three items, amphipods, fish, and crustacean larvae, contribured more than 10 percent each to the total volume of the pink salmon diet. Amphipods, again the major food item, accounted for 49.0 percent of the total volume. Pteropods, although found in a greater percentage of the stomaches in Region B than in Region A, accounted for only 3.5 percent of the volume. In Region C each of four items, copepods, euphausiids, emphipods, and fish, contributed more than 10 percent to the total food volume. Pteropods, although found in 41.1 percent of the stomachs, accounted for only 5.5 percent of the total volume.

Comparison of feeding behavior of the species

Fish taken in the same area, unless otherwise noted in table 1, were also taken with the same gear and in the same set. Therefore, it is reasonable to assume that all three species in a particular area had the same food supply available. Consequently, differences in stomach contents were attributed to differences in feeding behavior.

Figure 2 summarizes graphically the percentage of the total volume contributed by the different food organisms, and figure 3 summarizes the frequency of occurrence of the different food items in the diets of the three species of salmon from each of the three regions.

Region A: Amphipods were the most important single food item to the sockeye and pink salmon. The most important food item for the chum salmon was crustacean larvae. Only two items, amphipods and crustacean larvae, contributed in excess of 10 percent each to the total volume of the sockeye's diet. The remaining items contributed to the diet a total volume of only 9.4 percent. Each of five items contributed volumes in excess of 10 percent to the chum's diet, and four groups had a similar importance to the diet of the pink salmon. Thus, the sockeye appeared to be the most selective of the three species, whereas the chum and pink appeared to be more omnivorous feeders. Further differences might be evidenced by the fact that the frequency of occurrence of amphipods was almost the same in the diets of the three species, while the volumetric contribution of amphipods was about five times as great for the sockeye and pink salmon as it was for the chum. Copepods, entirely absent in the diet of the pink and sockeye, were found in chum salmon stomachs. Fish also were considerably more important to the diet of the chum and pink salmon than to the sockeye.

Region B: For all species, amphipods were the most important food item. Only one item, the amphipods, contributed a volume in excess of 10 percent to the sockeye's diet. Four groups each contributed volumes in excess of 10 percent to the chum's diet, while three items have a similar importance to the diet of the pink salmon. The amphipods occur with about equal frequency in the diet of all three species; however, volumetrically the amphipods were almost three times as important to the sockeye as to the chum salmon. The sockeye again demonstrated a greater selectivity than either the chum or the pink salmon.

The frequency of occurrence of copepods and euphausiids in the stomachs of the three species was another indication of the difference in their feeding behaviors. Copepods occurred in 44.4 percent of the chum stomachs, but in only 8.2 percent of the sockeye and 5.1 percent of the pink salmon stomachs. Euphausiids occurred in 55.1 percent of the chum stomachs, but in only 28.8 percent of the pink and 16.4 percent of the sockeye stomachs. Fish were of far greater importance to the pink salmon than to either the chum or the sockeye. Squid were of considerable importance to the chum diet, but played only a minor role in the diet of the pink and sockeye salmons.

Region C: Copepods were the most important food item to both the sockeye and pink salmon, although euphausiids also contributed substantially to the diets. Euphausiids and fish formed the bulk of the chum salmon diet. Three groups, copepods, euphausiids, and fish, contributed in excess of 10 percent each to the diet of the sockeye, while each of four groups contributed volumes in excess of 10 percent to the diets of the chum and pink salmon. Thus, the sockeye appeared to be the most selective of the three species in Region C. For all the species, amphipods appeared in a high

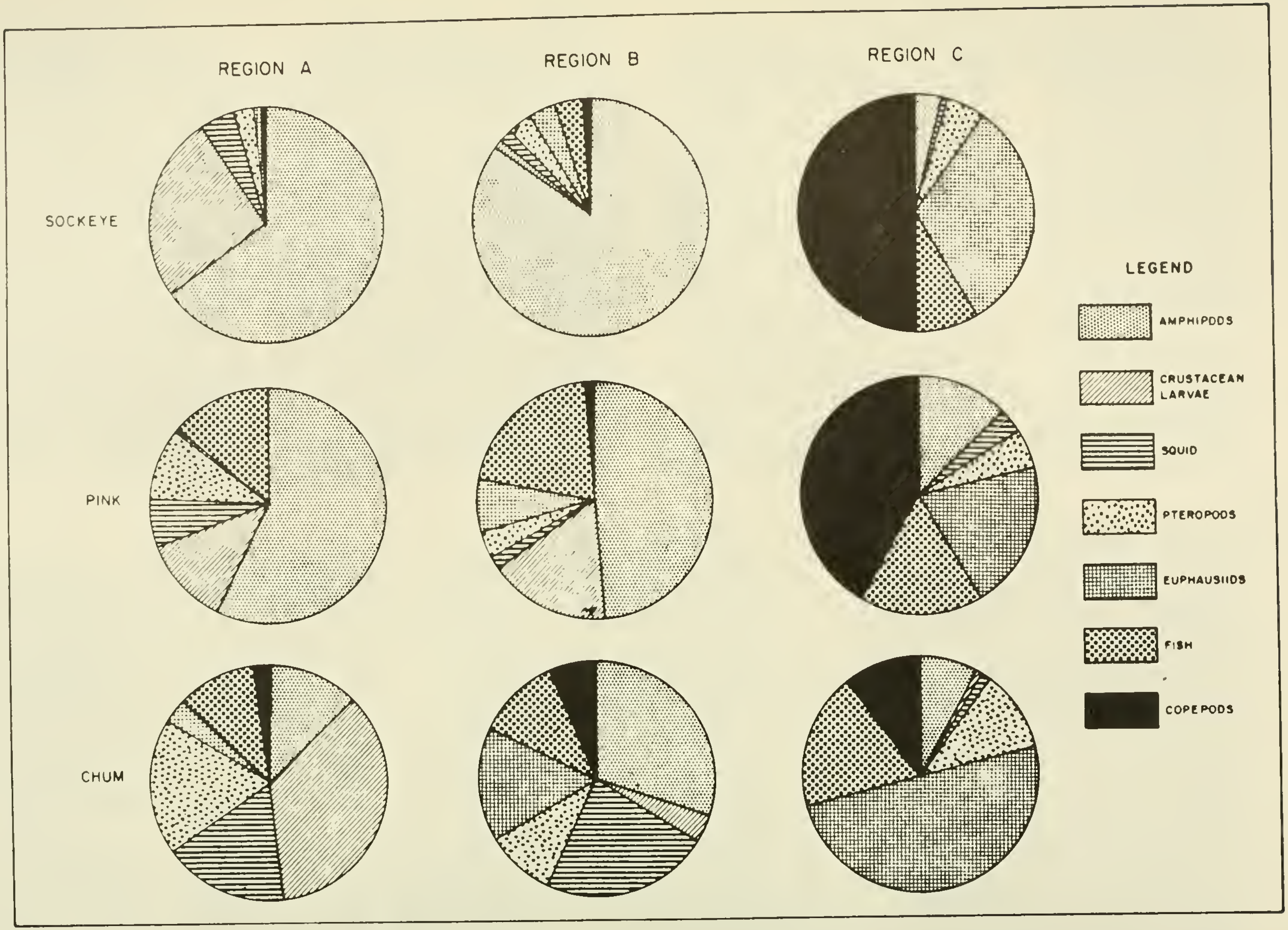

Figure 2.--Percent of the total volume contributed by the different food organisms.

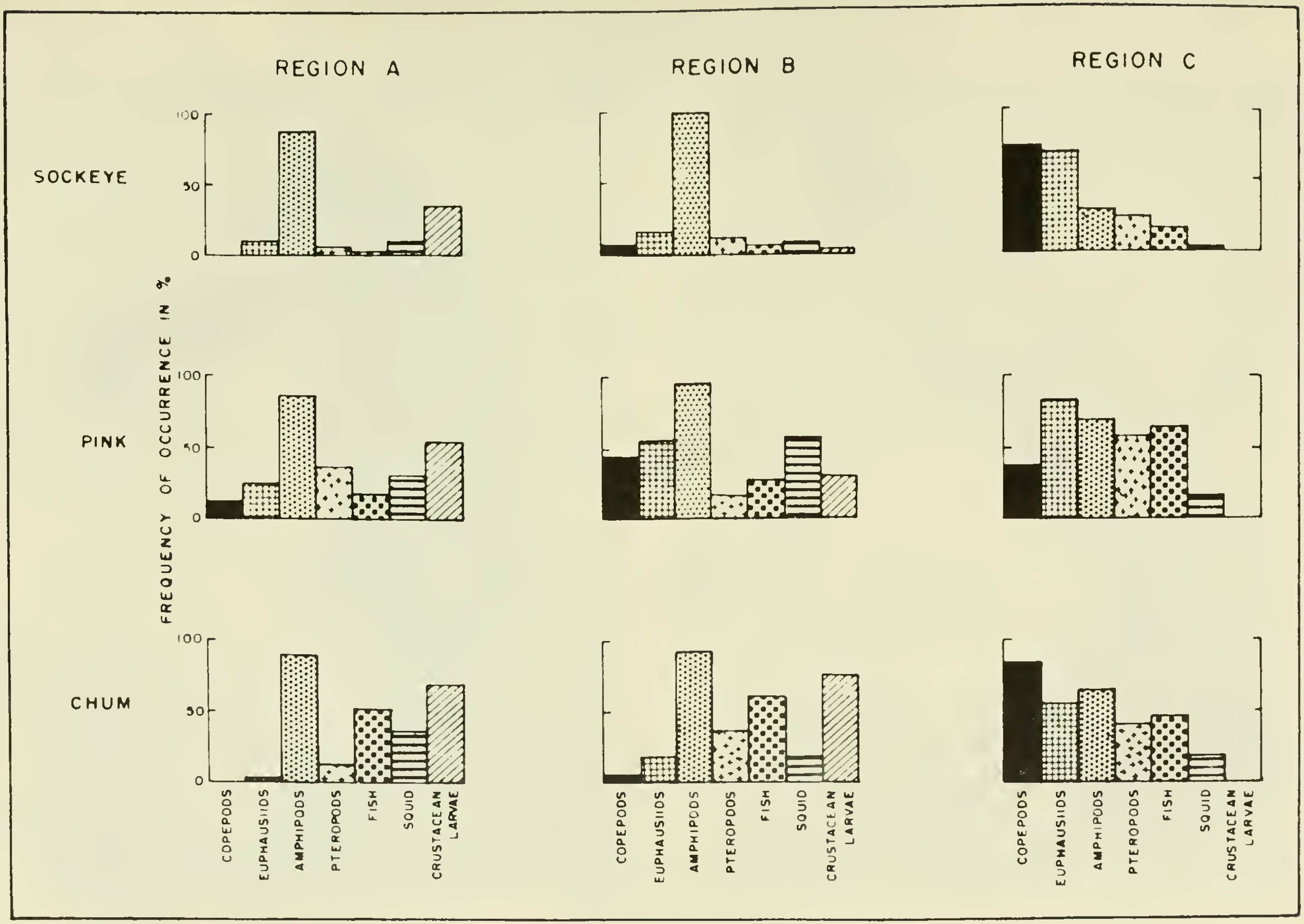

Figure 3.--Frequency of occurrence of different food items.

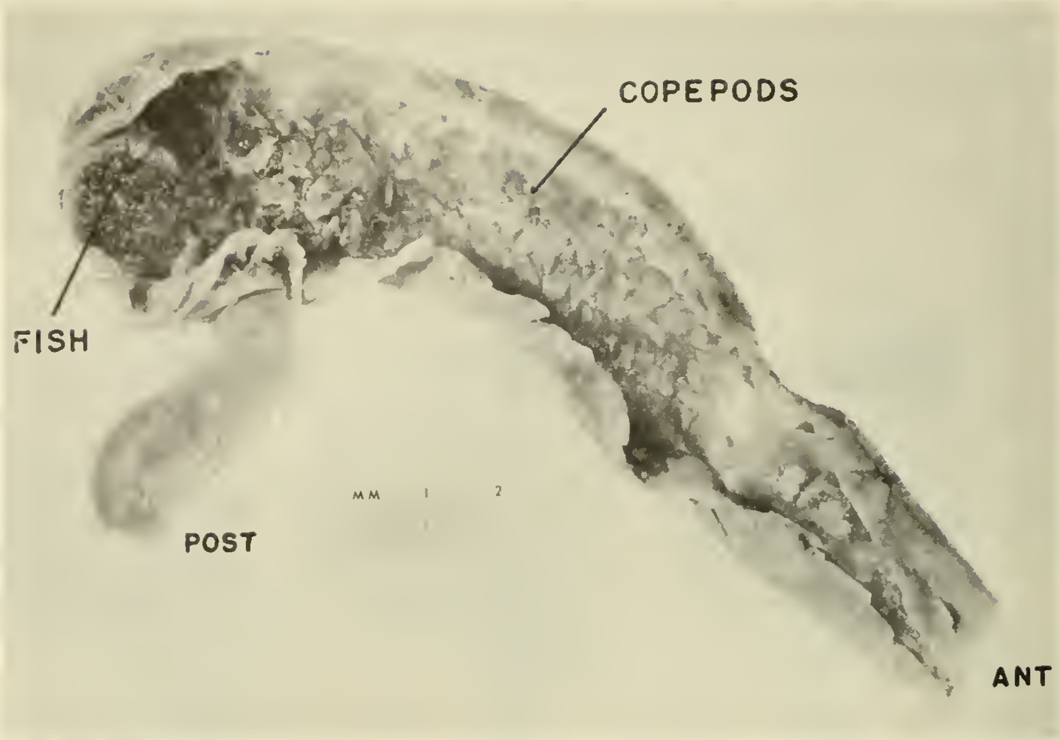

Figure 4.--Sockeye salmon stomach showing an almost pure content of copepods.

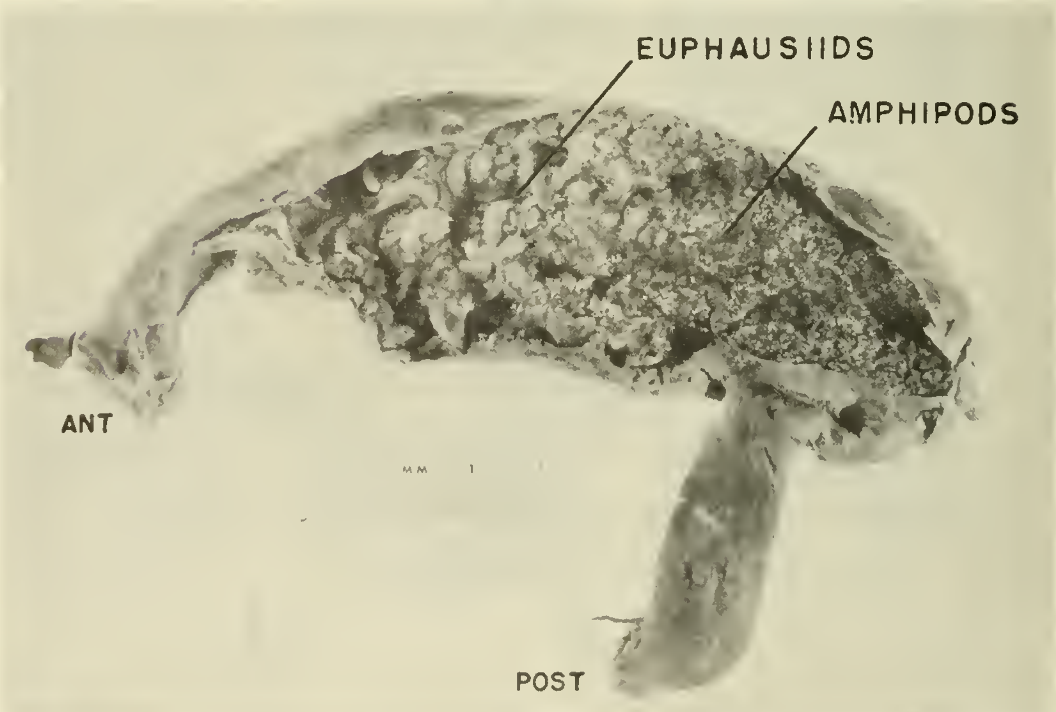

Figure 5.--Sockeye salmon stomach showing stratification of contents.

percentage of the stomachs; however, volumetrically they played a secondary role in the diets. Crustacean larvae are not found in any of the sockeye or pink salmon stomachs, although they did appear in 10.8 percent of the chum salmon. Fish were of lesser importance to the sockeye than to the pink and chum salmons.

Identification of food items in the stomach contents

Complete species identification was not possible at this time. Some of the more important food items, however, have been identified. Of the copepods, the greatest number were of the genus *Calanus*. *C. eristatus* was a very common species, perhaps even the predominant species. A few specimens of another copepod, *Metridia lucens*, were also identified. None of the Euphasiids have been identified. It appeared, however, that only a single species, probably Thysanoessa sp., was of any importance to the diet of the salmon. Five species of amphipods were identified from the stomachs. These are the gammarid, *Scopelocheirus coecus*; and the hyperiids, *Hyperia gaudichaudii*, *Parathemisto japonica*, *P. libellula*, and *Primno* n. sp. Of these species only *P. japonica* was of any importance and it probably accounted for over 90 percent of the total amphipods. The pteropod found was almost always *Limacina* sp., although there were a few specimens of *Euclio* sp. The fish found were mostly lantern fishes, family Myctophidae, and juvenile rockfishes, *Sebastodes* sp. None of the squid were identified. The crustacean larvae, primarily megalops and zooea stages of decapods, also were unidentified.

Patchiness of organisms and selectivity of feeding

Some of the stomachs contained a single species but more typically, particularly for the sockeye, a single species accounted for more than 90 percent of the volume of the diet. An example of a stomach with an almost pure content of copepods is shown in figure 4. The contents of a number of other stomachs, rather than being a homogeneous mixture, were definitely stratified. An example of this for the sockeye salmon is shown in figure 5. The contents of the posterior region of this stomach were entirely emphipods, *Parathemisto japonica*, while the anterior portion was filled with euphausiids. Similarly stratified stomachs were found in chum and pink salmon.

The above results can be best explained by assuming a non-homogeneous distribution of food organisms and some degree of feeding selectivity by the fish. The stratified stomach shown in figure 5, for example, was taken from a fish capture in Area 12. The dominant item in the diet of 17 fish from this area was the amphipod, *P. japonica*; the stomach of one fish contained only euphausiids, while the stomach of another fish (shown in fig. 5) contained one-half amphipods and one-half euphausiids. If the amphipods and euphausiids were well mixed in the area where the fish were feeding, it would be necessary to assume a high degree of feeding selectivity on the part of the fish. If, however, those food organisms had a patchy distribution, and the amphipod patches were larger or more numerous than the euphausiid patches, it is not necessary to assume that the fish fed with extreme selectivity. A fish found to have a stomach containing only amphipods would have confined its feeding to the amphipod patches; a fish found to contain only euphausiids had fed only in a euphausiid swarm; while fish in which the stomach contents was stratified had fed first in one swarm and then in another.

Discussion of Results

The basic assumption in analyzing the information reported in this study is that fish taken in the same area at the same time, and in the same gear, had the same food supply available. Differences in stomach content would then reflect differences in feeding behavior. This assumption may be challenged on several points:

1. The size of the sample may not have been adequate for the three species.

2. The fish may not have been caught in the area in which they had fed; therefore, the various species may have been exposed to different food supplies prior to their capture.

3. The time of feeding of the three species in the same area may have been different. Diurnal plankton

variations would then expose fish feeding at different times to different food supplies.

The first objection to the assumption is the one most easily overcome. Variation between the stomach contents of the same species taken in the same area was small. This lack of variation probably makes the sampling size adequate.

The second criticism is not so easily overcome. All evidence at present points to the fact that the bulk of the salmon in oceanic waters are found in the surface layers (Barnaby, 1952; Fukuhara, 1953; Tanonaka, 1955). If the differences in feeding behavior were due to the fish feeding in areas other than their point of capture, it is probable that the differences in feeding were due to the salmon's horizontal rather than vertical distribution. If this criticism to the hypothesis is valid, then a wide variation in feeding behavior in the different areas would have been expected; however, the stomach content of fish from various areas of a single region showed little such variation. Different species exposed to the same food supply consistently fed differently. From area to area, for example, the sockeye was consistently more selective than the chum salmon.

The third objection cannot be resolved at the present stage of our knowledge. There was some indication, in fact, that diet differences were due to time differences in feeding. The contents of chum salmon stomachs were, on the average, further digested than the contents of either the pink or the sockeye. This may be due to differences in digestive rates, but it may be due also to a difference in the feeding time. Further information concerning the digestive rates of the Pacific salmon is necessary to determine the validity of this objection.

Even if the objections are valid, the fact remains unaltered that different species of salmon feed differently. The data seem to indicate that the sockeye is the most selective and the chum the most omnivorous feeder of the three species. The feeding behavior of the pink salmon seems closer to the chum than to the sockeye. Feeding behavior of fish in different regions was also different. This, of course, is a reflection of the varying availability of the different food organisms. In the inshore waters amphipods and, to a lesser degree, crustacean larvae formed the major portion of the food supply. As the waters became more oceanic, copepods and euphausiids assumed increasing importance. Amphipods seemed ubiquitous, appearing with great frequency in all regions. Copepods and euphausiids, however, assumed roles of importance only in the more oceanic waters. This does not mean that euphausiids and copepods may not have been in the inshore waters. It means only that they were not utilized by the salmon in the inshore waters at the time of the year when the samples were taken.

Qualitatively, the items consumed by the three species were similar. The differences established were mainly quantitative. Size of food items also was involved in feeding behavior (table 7). Chum salmon tended to feed more on the larger forms (squid, fish, and euphausiids). Sockeye fed more on the smaller forms (amphipods and copepods). Pink salmon were intermediate in degree of selectivity of food items. Table 7 also indicates that the larger food organisms became more important in the diet of all three species as the area became more oceanic.

Table 7.--Percentage contribution by volume of fish, squid, and euphausiids to the diet of the sockeye, pink, and chum salmons

Species	Region A	Region B	Region C
Sockeye	6.5	10.0	42.0
Pink	20.7	29.8	40.3
Chum	30.7	50.7	70.2

It is emphasized that the data presented were only for a portion of one year. It may be expected that seasonal variation played an important part in determining the availability of food and the resulting diets of the salmon. In Region A, for example, crustacean larvae were an important part of the fishes' diet for the time of the year under consideration. These larvae, however, are meroplankton and it may be expected that their availability throughout the year would fluctuate

considerably. Also, feeding habits probably change with the size and increasing maturity of the fish.

The true extent of feeding selectivity of the salmon cannot be understood until a more comprehensive understanding of plankton populations is reached. No positive relationship between the animals found in stomach contents and plankton samples has been established (Allen, 1956; Nakai and Honjo, 1954; Seelinger, personal communication).

At present, extensive research is being carried out at this laboratory, using a 6-food model of the Isaacs-Kidd midwater trawl towed at speeds ranging from 5 to about 8.5 knots. The mesh sizes in the net are such that both fish and plankton are caught in the same haul. Preliminary analyses of the stomach contents of fish caught in these hauls as compared with the plankton caught in the hauls show a high correlation. It is possible that the Isaacs-Kidd trawl will be a satisfactory device for sampling the food of the salmon.

Acknowledgements

Appreciation is expressed for the assistance of Dr. Richard H. Fleming and Mr. Phillip Seelinger of the Department of Oceanograhhy, University of Washington; Mr. C. E. Atkinson of the Pacific Salmon Investigations, U. S. Fish and Wildlife Service; and Dr. Clarence Shoemaker and Dr. Thomas Bowman of the U. S. National Museum.

Literature Cited

Allen, George H.
1956. Notes on the relationship between plankton sampling and the food of the Pacific salmon. University of Washington, Department of Oceanography, Fishery Report No. 3. 36 pp. (mimeographed)

Barnaby, J. T.
1952. Offshore fishing in Bristol Bay and Bering Sea. U. S. Dept. of the Interior, Fish and Wildlife Service, Special Scientific Report--Fisheries No. 89. 30 pp.

Fukuhara, F. M.
1953. Japanese 1952 North Pacific Salmon-Fishing Expedition. U. S. Dept. of the Interior, Fish and Wildlife Service, Commercial Fisheries Review, 15(2): 1-17.

Nakai, Z., and K. Honjo
1954. A preliminary report on surveys of plankton and salmon stomach contents from the North Pacific, 1952. Japan, Fisheries Agency, Min. Agric. and Forest., Tokai Reg. Fish. Res. Lab., Spec. Publ., No. 3: 6-12.

Redfield, Alfred C.
1941. The effect of the circulation of water on the distribution of the calanoid community in the Gulf of Maine. Biological Bulletin LXXX (1): 86-110.

Tanonaka, G. K.
1955. Cruise of the M. V. Mitkof, 24 July - 5 October 1955. U. S. Dept. of the Interior, Fish and Wildlife Service, Seattle, (Typewritten report).

INT.-DUP. SEC., WASH., D.C. 31415